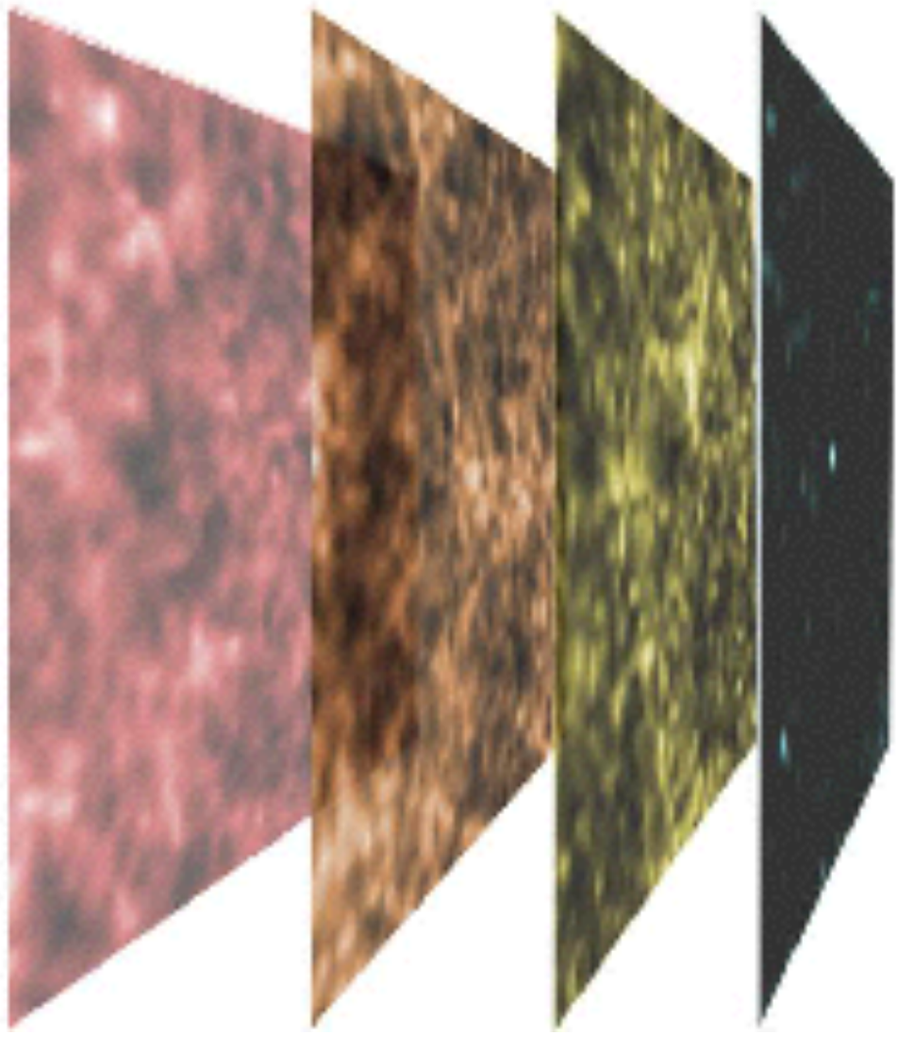
Intensity Mapping: Cross-correlations



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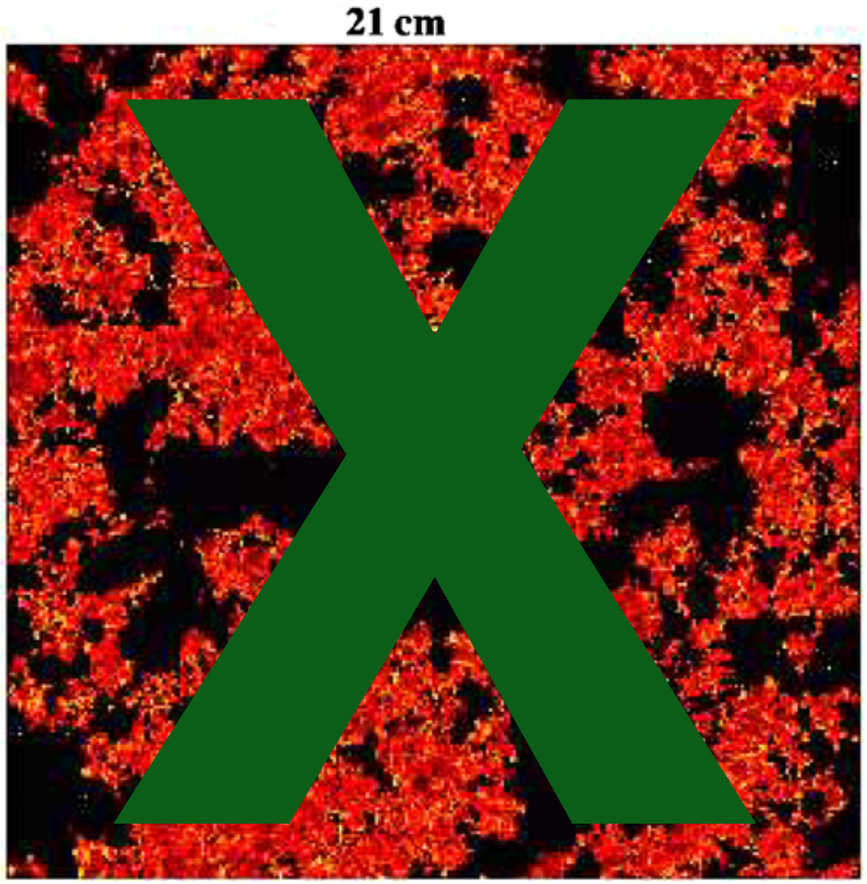
Friday, Sept 23, 2016

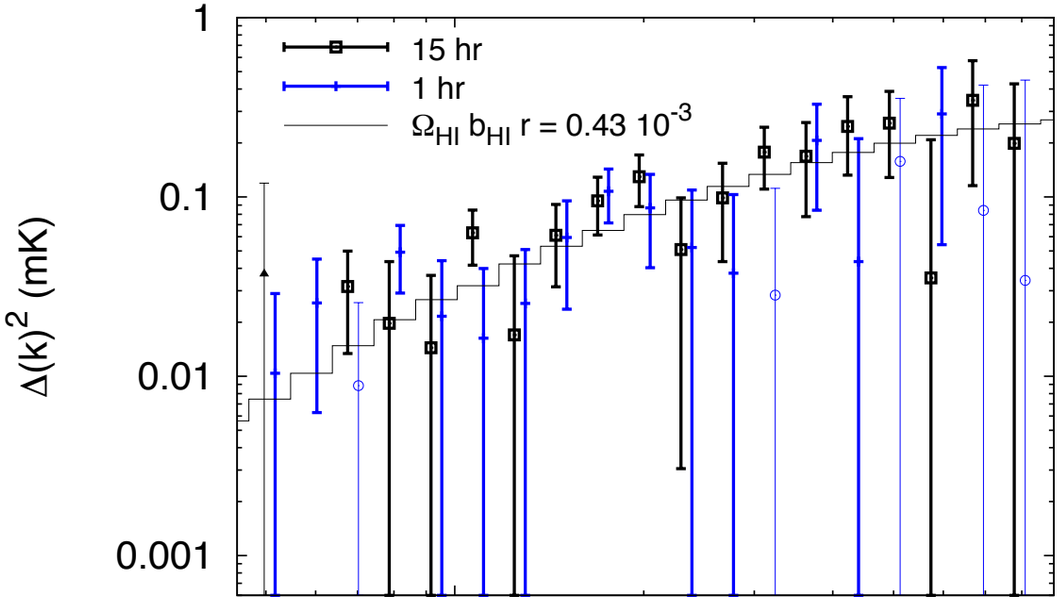
DOE Science Only



- Show current constraints

Cross-correlate with Galaxies?

- Traditionally used to measure intensity
- Could help calibrate photo-z's
- Maybe use for higher redshift studies (z > 2)?
- Limited by intensity $k_{\parallel,min}$ and galaxy $k_{\parallel,max}$



Credit: Masui 2013

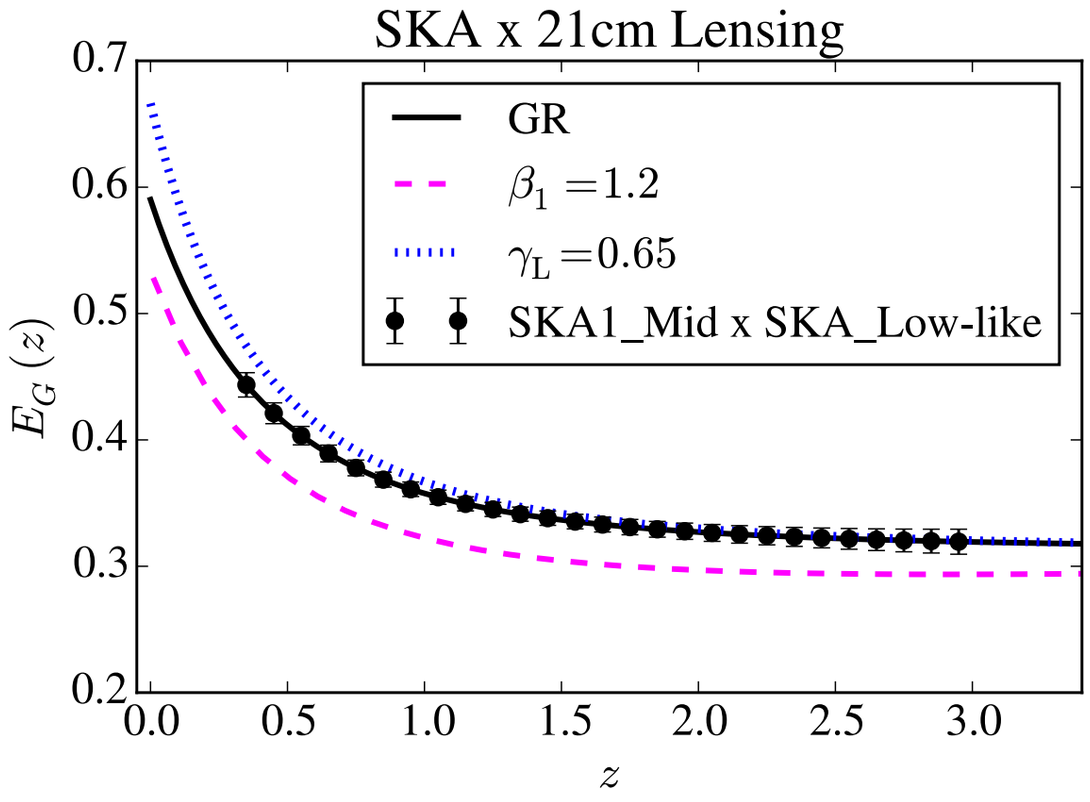
E_G (Gravity Test)

- Gravity-testing statistic combining RSD and lensing (CMB - Pullen et al. 2015)

- Lensing of 21-cm maps would have 30x better convergence reconstruction than *Planck*

- SKA would measure E_G with <1% errors

- Maybe measure I factor through shot noise (at low redshift)



Credit: Pourtsidou 2015

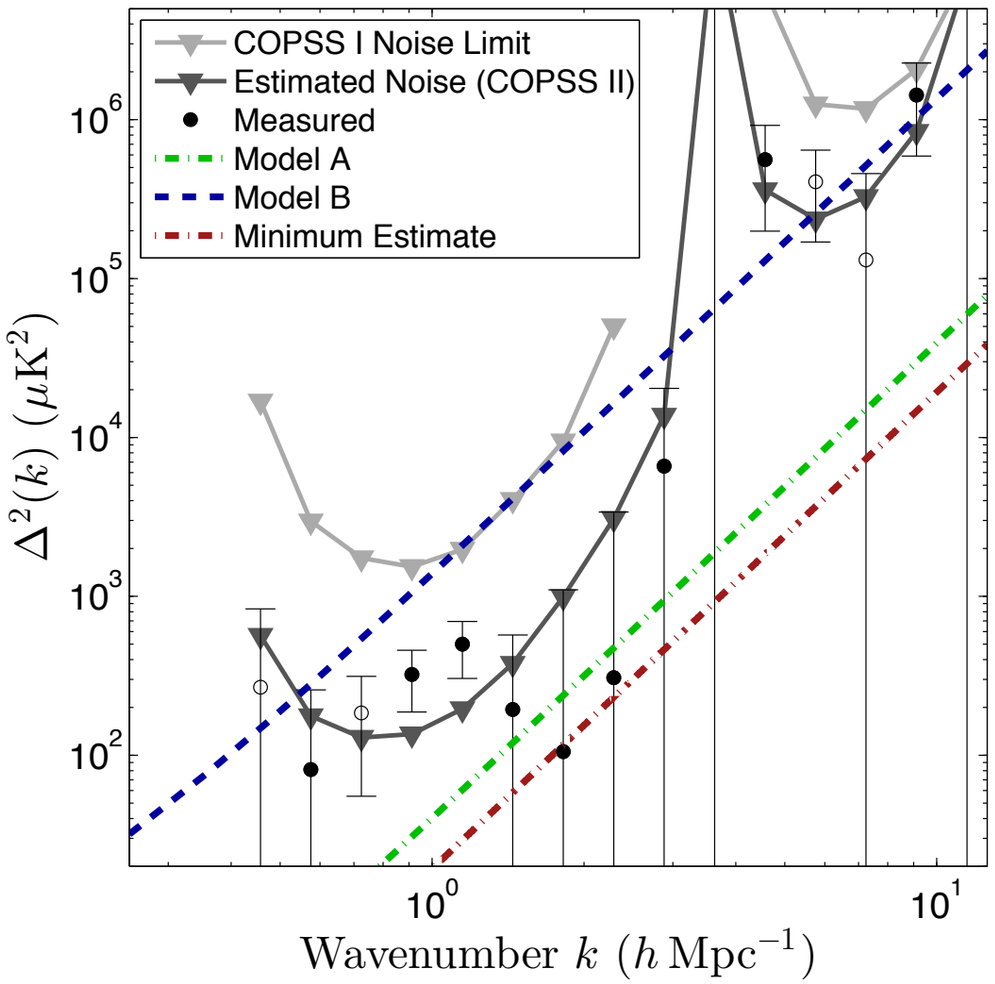
$$E_G = \Gamma \frac{\overline{I} C_\ell^{\kappa I}}{\beta C_\ell^{II}}$$

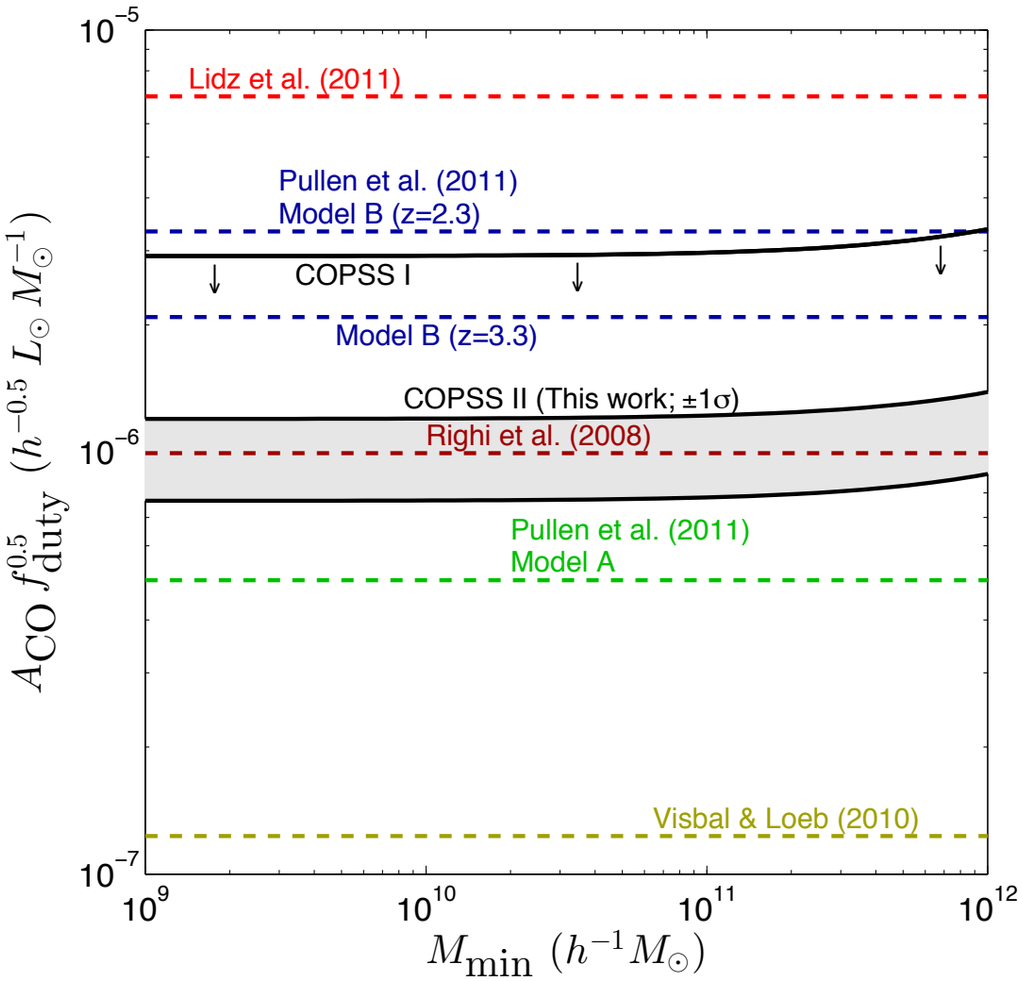
21cm x Other Lines

- Isolates structure at one redshift
- Reduces foreground bias relative to 21cm auto-power
- Could be performed in one instrument with a large spectral range
- Common foregrounds (e.g. sky continua) are a concern
- Could it compete with galaxy surveys?

Can we probe neutrinos with cross-correlations?

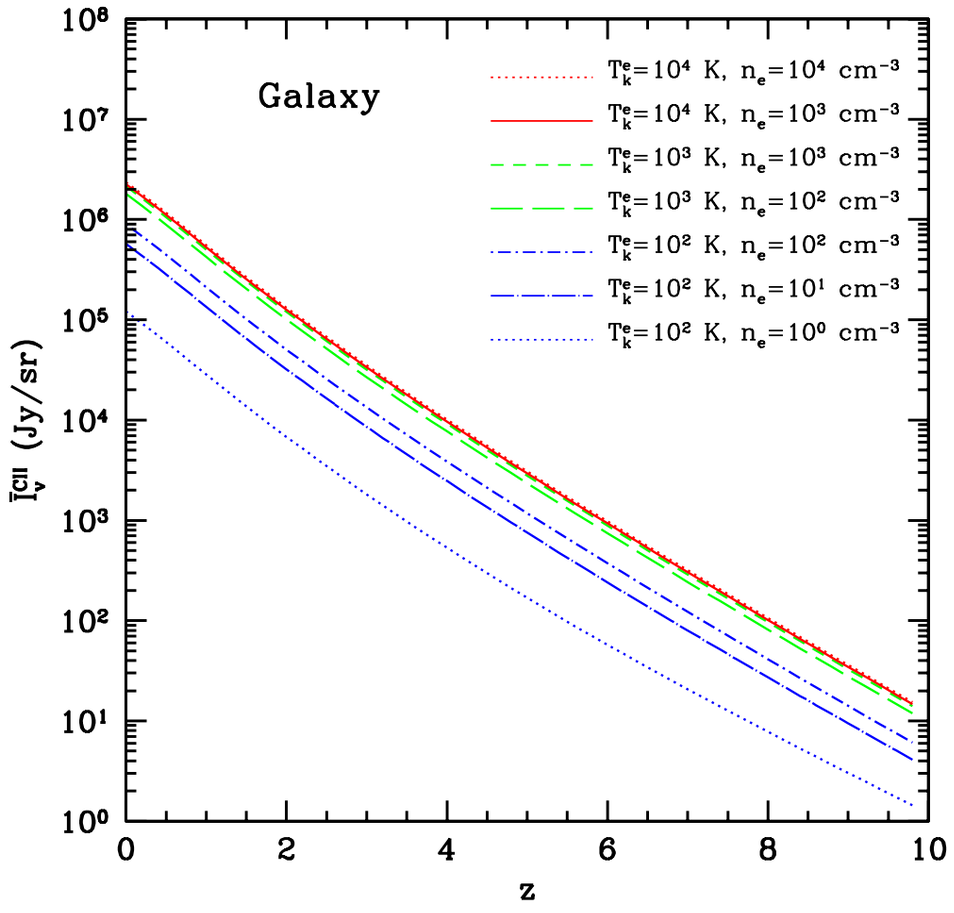
Carbon Monoxide



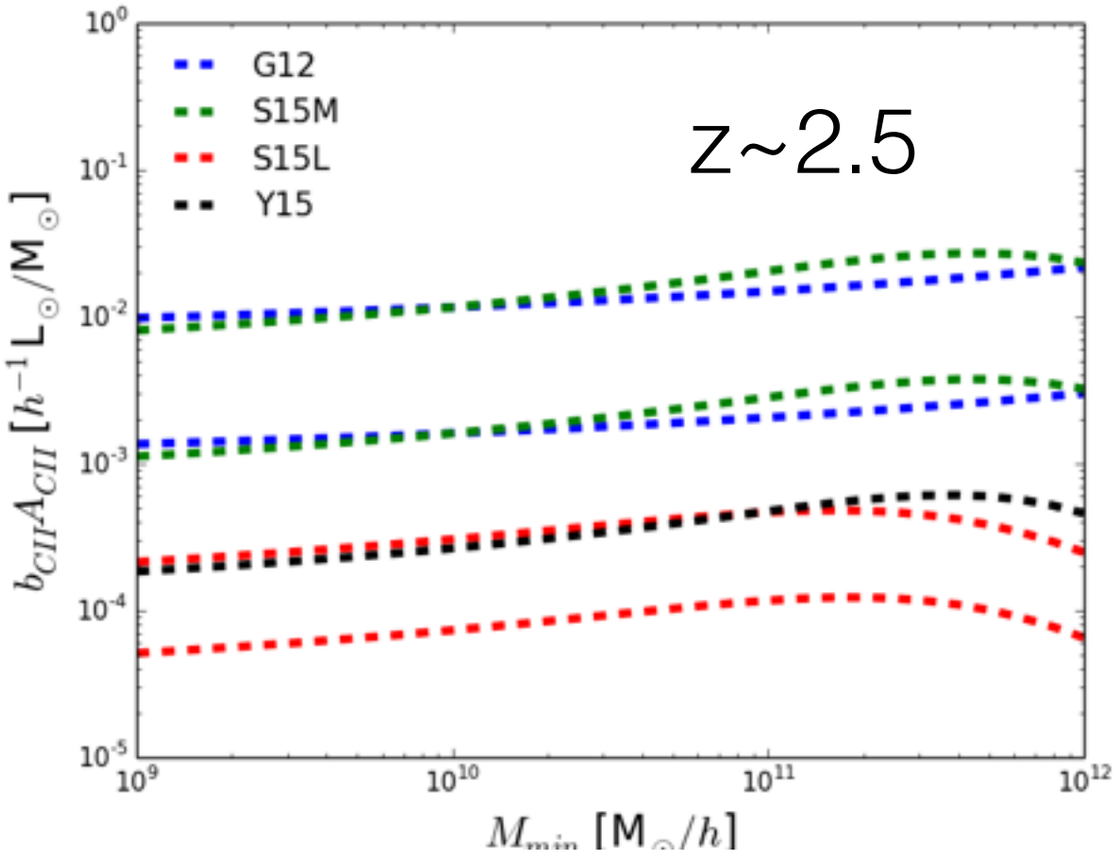


Keating et al. 2016

CII Emission

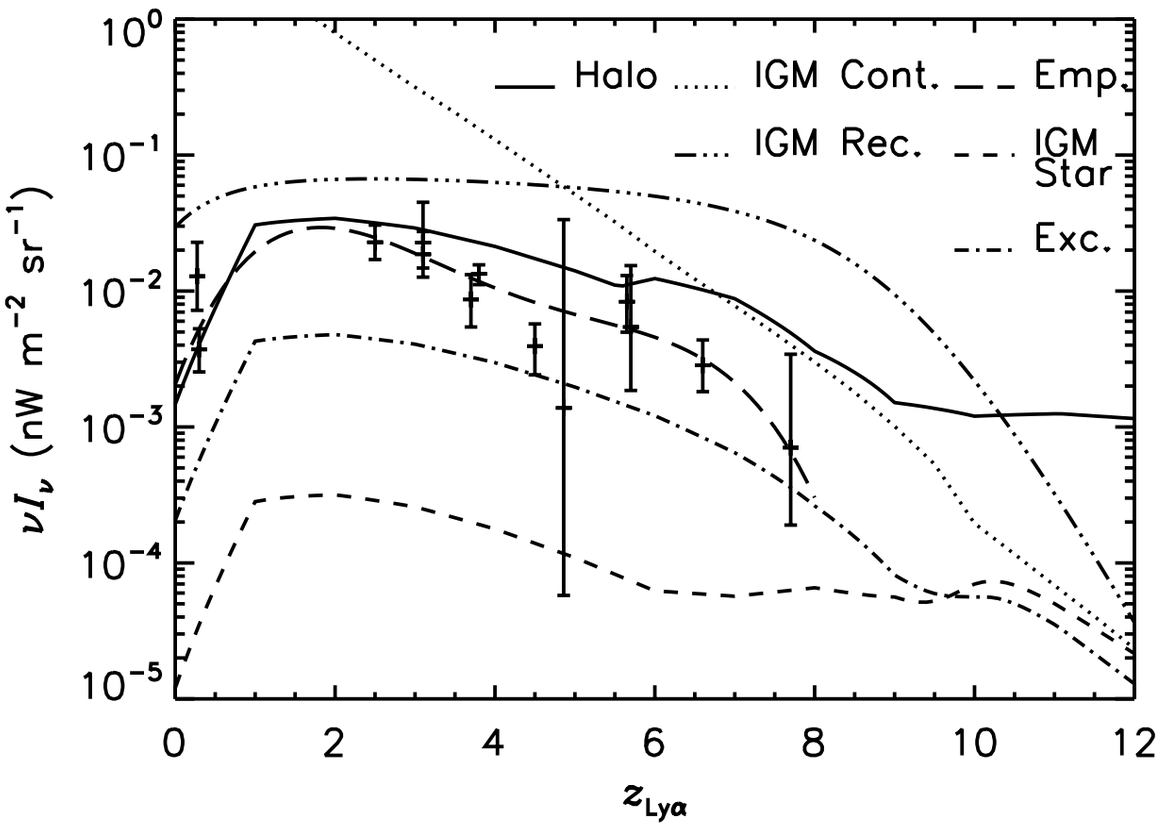


Credit: Gong 2012

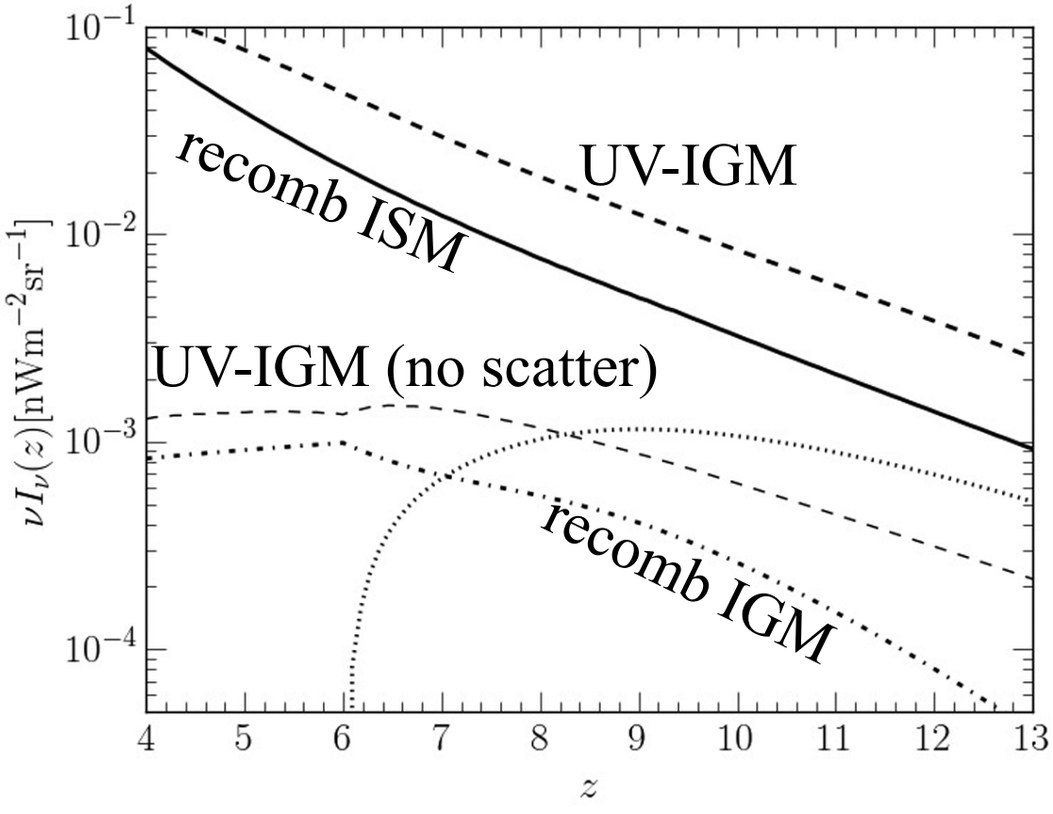


Gong et al. 2012, Silva et al. 2015, Yue et al. 2015

Lyα Emission



Credit: Pullen, Doré & Bock 2014

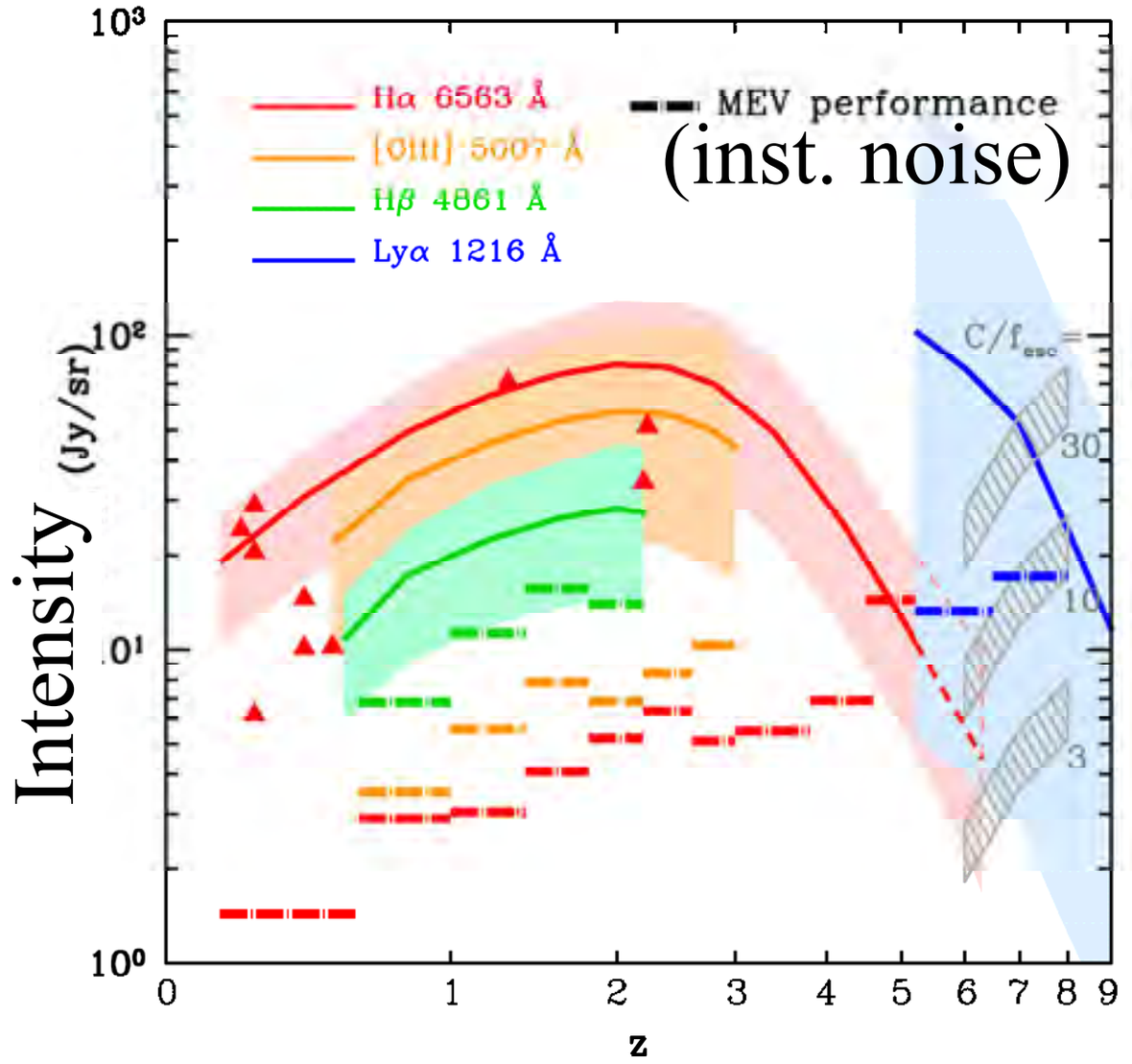


Credit: Comaschi & Ferrara 2016

Pathfinders (COMAP, TIME-Pilot, etc.)
will nail these down

SPHEREx could probe large scales

- IM survey of 12 Gpc^3 (Hα) and 6 Gpc^3 (Lyα)
- $k_{\parallel,max}$ = 0.08 h/Mpc (Hα) and 0.02 h/Mpc (Lyα)
- Test luminosity models
- Lyα x Hα correlation
- **Need more like this**



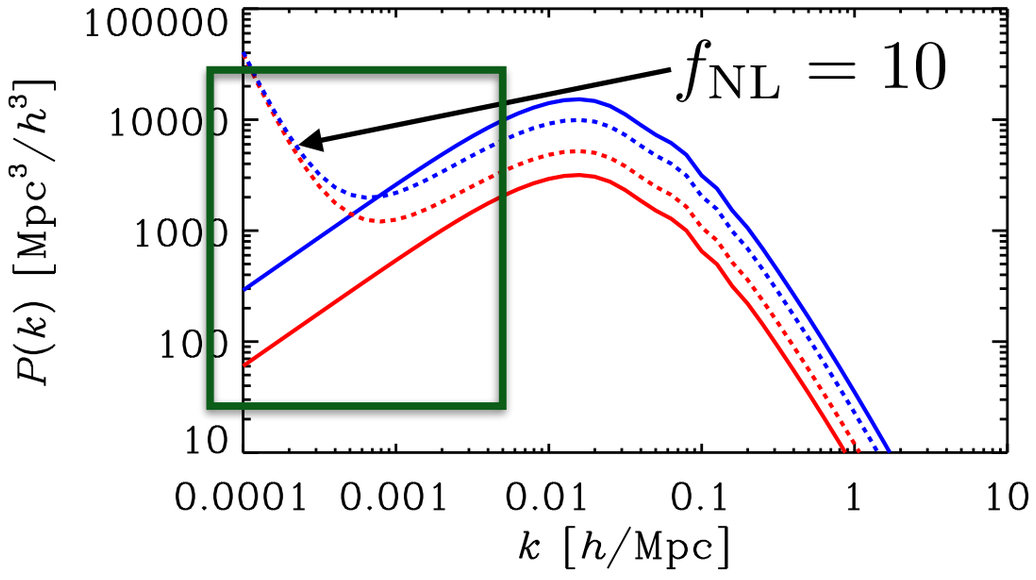
spherex.caltech.edu

Summary

- There is a DOE science case for a multi-line survey
- We need more science papers
- Pathfinder surveys will help

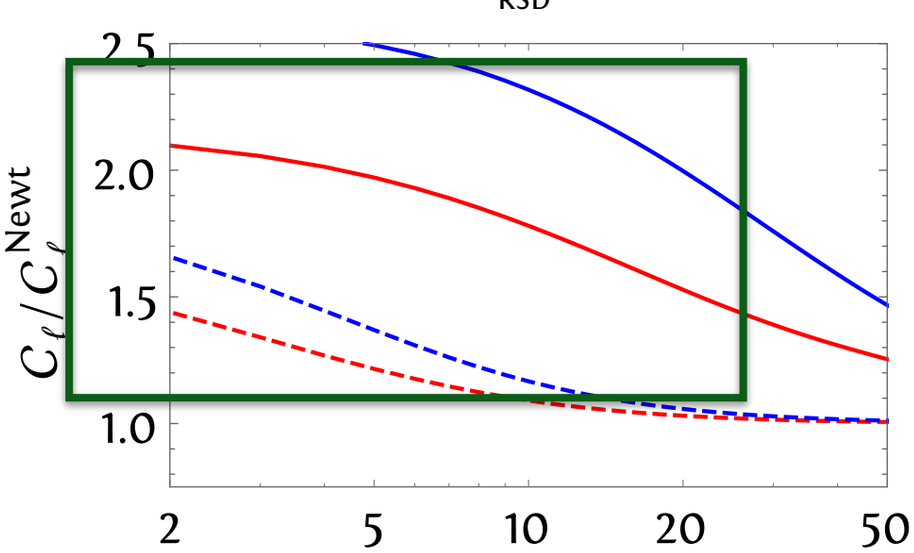
Extra Slides

Non-Gaussian Inflation



Credit: Camera et al. 2013 (SKA)

General Relativity Test

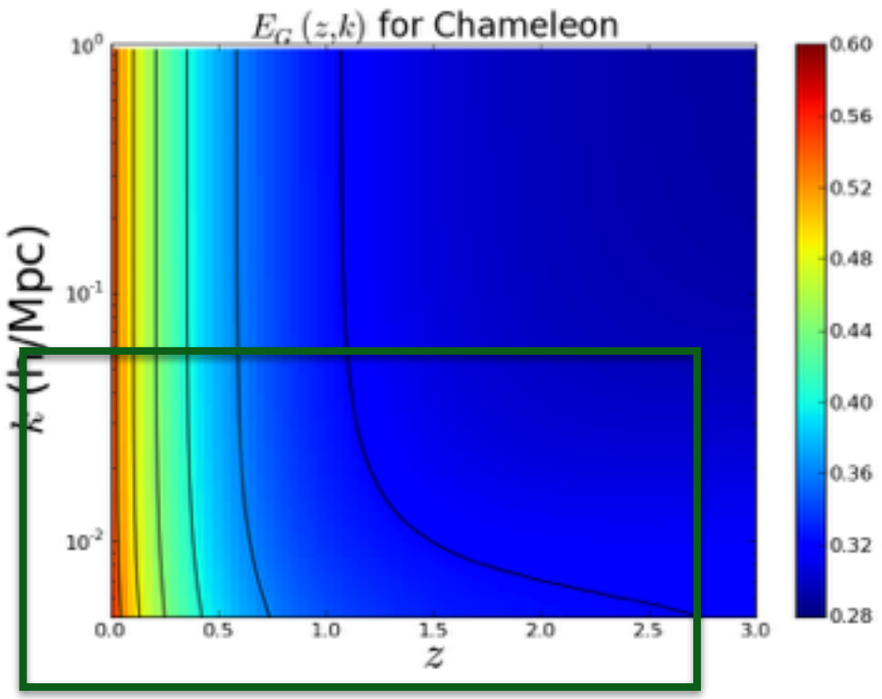


Credit: Camera et al. 2015 (SKA)

$$E_G \sim \left| \frac{\nabla^2 \phi}{\nabla \cdot v} \right|$$

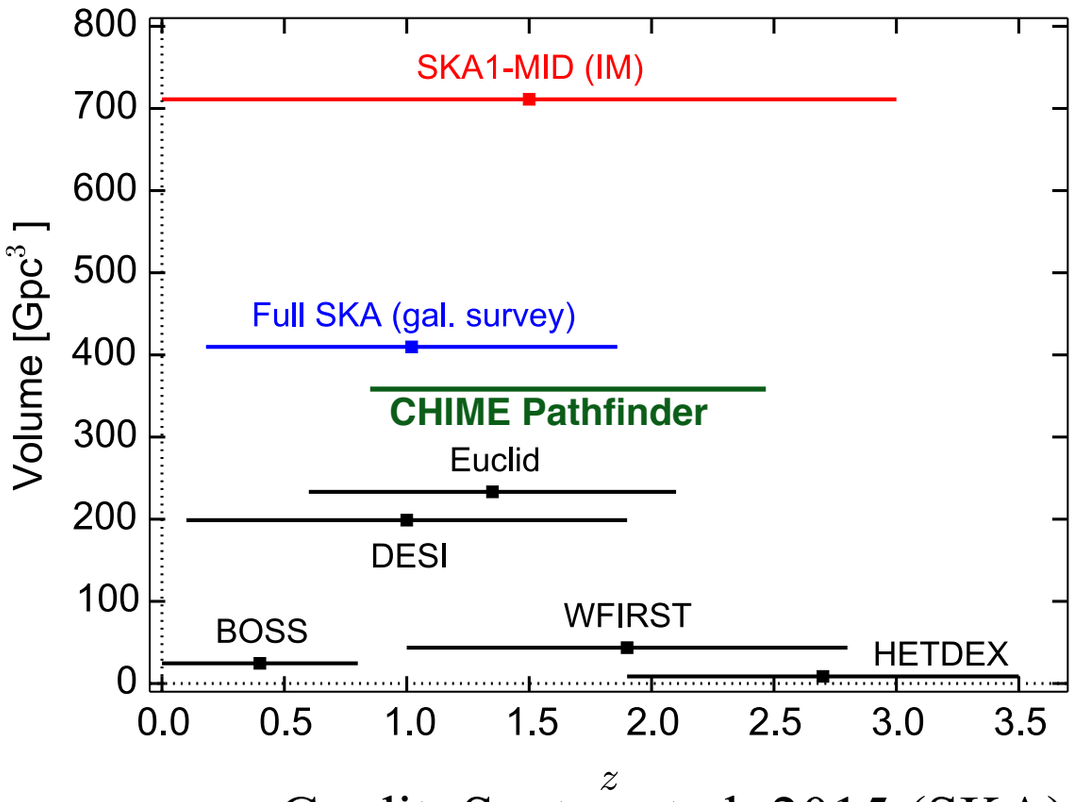
Modified Gravity Search

Credit: **Pullen**, Alam, & Ho 2015 (SKA)



Large-Scale Phenomena

IM probes the largest volumes



Credit: Santos et al. 2015 (SKA)

- Probes the largest scales with many modes
- Ideal for non-gaussianity, GR tests, modified gravity